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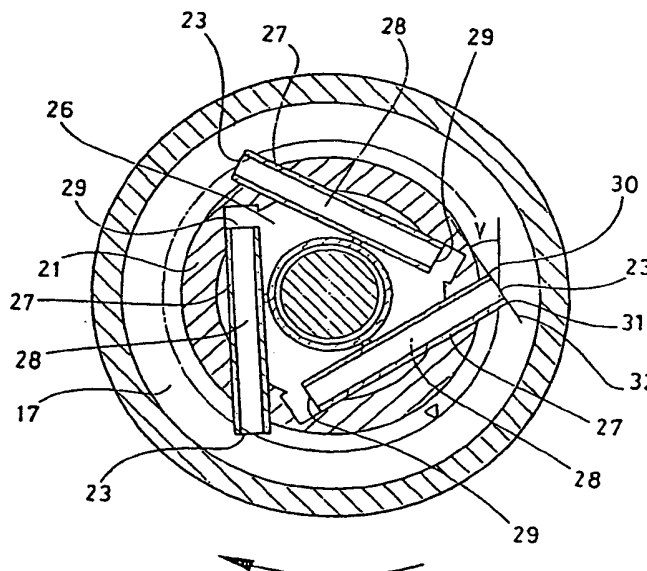
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(54) Title: CENTRIFUGAL SEPARATOR

(57) Abstract

Centrifugal separator comprising a rotor, which forms an inlet for the liquid which is to be centrifugally treated and an outlet chamber (17) for a liquid separated in the rotor, the outlet chamber (17) surrounding the rotational axis and being so designed that liquid present in the outlet chamber during operation rotates around the rotational axis and has a radially inward facing circular free liquid surface at a certain radial level in the rotor. A stationary discharge device (21) extends in the outlet chamber (17) from the said liquid body radially inward to a central outlet (25) and in the area of the free liquid surface it forms an inlet opening (23), which is directed toward the rotational direction of the liquid body and partly is located in the liquid body, the discharge device also forming a flow channel (28), which connects the inlet opening (23) to the central outlet. To obtain a high outlet pressure with minor risk of air admixture and a good stability the inlet opening (23) is delimited by an edge, which upstream has a front edge portion (33) radially inside the free liquid surface and downstream has a rear edge portion (31) radially outside the free liquid surface, a straight line (32) drawn through said edge portions (30, 31) forming an angle (V) with a tangent to the free liquid surface at the inlet opening (23), the angle being greater than 20° but smaller than 50° and the vertex of the angle being directed in the rotational direction.



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## CENTRIFUGAL SEPARATOR.

The present invention concerns a centrifugal separator comprising a rotor, which is rotatable around a rotational axis and forms an inlet for the liquid to be centrifugally treated and an outlet chamber for a liquid separated in the rotor, the outlet chamber surrounding the rotational axis and being so designed that liquid present in the outlet chamber during operation forms a rotating liquid body around the rotational axis which has a radially inward facing free circular liquid surface at a certain radial level in the rotor. The centrifugal separator also comprises a stationary discharge device, which in the outlet chamber extends from the said liquid body radially inward to the central outlet and in the area of the free liquid surface forms an inlet opening, which is directed towards the rotational direction of the liquid body and partly is located in the liquid body, the discharge device also forming a flow channel, which connects the inlet opening to the central outlet.

A centrifugal separator of this kind is shown in WO 88/102664. By the fact that the inlet opening of the outlet device in this centrifugal separator only partly during operation is located radially outside the free liquid surface also a liquid of a high viscosity can be separated in and discharged out of such a centrifugal separator. However, the flow conditions in the flow channel nearby the inlet opening are such that a part of the liquid of high viscosity flowing into the flow channel turns and flows out again into the outlet chamber through the part of the inlet opening located radially inside the free liquid surface. This results in a low outlet pressure, a great risk of air admixture and an increased risk of instability.

If you try to reduce the return flow of separated liquid from the flow channel out through the inlet opening to the outlet chamber by diminishing the radius of the free liquid surface a wave is created in front of the inlet opening and the energy consumption increases in a high degree and the outlet pressure becomes low.

The object of the present invention is to provide a centrifugal separator of the kind initially described, in which also a liquid of higher viscosity than 100 cSt can be separated and discharged out of the outlet chamber with a satisfactory high outlet pressure and low risk of air admixture and instability.

This object is achieved by designing a centrifugal separator of this kind with an inlet opening, which is delimited by an edge, which upstream the inlet opening has a front edge portion radially inside the free liquid surface and downstream the inlet opening has a rear edge portion radially outside the free liquid surface, a straight line drawn through said edge portions forms an angle with a tangent to the free liquid surface at the inlet opening, the angle being greater than  $20^\circ$  but smaller than  $50^\circ$  and the vertex of the angle being directed in the rotational direction.

By designing the inlet opening in this way you bring the part of the separated liquid, which flows out again through the inlet opening, immediately to flow against the free liquid surface, so that it once again is conducted into the flow channel.

In a preferred embodiment of the invention the discharge device has at least one tubular element, which forms a part of the flow channel, and which is located in the

rotating liquid body with its radially outermost part during operation while the remaining parts of the discharge device are located radially inside the rotating liquid body.

5

In order to make adjustment of the radial position of the free liquid surface possible there is proposed in another embodiment of the invention that the tubular element is arranged movable in the discharge device in  
10 such a way that the inlet opening of the flow channel can be placed at a variable radius.

The tubular element is then preferably arranged movable along its longitudinal axis.

15

In a special embodiment of the invention a flow channel comprises a central flow chamber in the discharge device, which flow chamber is circular cylindrical and surrounds the rotational axis concentrically.

20

In the following the invention will be described more closely with reference to the attached drawings, in which

25 Fig 1 schematically shows an axial section through a part of a centrifugal separator according to the invention, and  
Fig 2 shows a section along the line II-II in figure 1.

30 In figure 1 there is shown a part of a centrifugal separator comprising a rotor, which has a lower part 1 and an upper part 2, which are joint together axially by means of a locking ring 3. Inside the rotor there is arranged an axially movable valve slide 4. This valve  
35 slide 4 delimits together with the upper part 2 a

separation chamber 5 and is arranged to open and close an outer passage between the separation chamber 5 and the outlet opening 6 to let out a component which has been separated from a mixture supplied to the rotor and being collected at the periphery of the separation chamber 5 intermittently. The valve slide 4 delimits together with the lower part 1 a closing chamber 7, which is provided with an inlet 8 and a throttled outlet 9 for a so called closing liquid. During rotation of the rotor the valve slide 4 is pressed by the pressure from the closing liquid present in the closing chamber 7 during influence of the centrifugal force into sealing abutment against a gasket 10 arranged in the upper part 2.

15 Inside the separation chamber 5 a disc stack 11 consisting of a number of conial separation discs is arranged between a distributor 12 and a top disc 13. In the example shown in figure 1 the rotor is mounted on a hollow shaft 14, through which the liquid to be centrifugally treated is supplied to the rotor. The top disc 13 forms at its in the figure shown upper end a centrally located first outlet chamber 15 for a specific lighter liquid component separated in the separation chamber 5. This first outlet chamber 15 communicates with the separation chamber 5 via a first overflow outlet 16, over which the specific lighter liquid component can flow out of the separation chamber 5.

30 The upper part of the rotor 2 forms a centrally located second outlet chamber 17, into which a specific heavier liquid component can flow from a radially outer portion of the separation chamber 5 via a passage 18 and a second overflow outlet 19.

In each outlet chamber there is arranged a stationary discharge device, a first discharge device 20 and a second discharge device 21. These discharge devices are provided with peripheral inlet openings, first inlet  
5 openings 22 and second inlet openings 23, respectively, which are connected to central outlets, a first outlet 24 and a second outlet 25, respectively. The discharge devices 20 and 21 extend mainly perpendicular to the rotational axis radially so far out that they during  
10 operation partly are located in a rotating liquid body located in the outlet chamber 15, 17 respectively.

As shown in figure 1 and 2 a flow chamber 26 is formed in a radially inner part of the second discharge device  
15 21. In the shown example the flow chamber 26 is circular cylindrical and surrounds the rotational axis concentrically. At the radially outer part of the second discharge device 21 the same is provided with three straight tubular elements 27, which partly project  
20 radially out from the radially inner part of the second discharge device 21. Each tubular element forms inside itself a flow channel 28, which has a peripheral inlet opening 23 facing towards the rotational direction of the rotor and an outlet opening 29, which opens into the  
25 flow chamber 26. The tubular elements extend so far radially out in the outlet chamber 17 that the inlet openings 23 partly during operation are located radially outside the free liquid surface. Upstream the inlet opening 23 has a front edge portion 30, which during  
30 operation is located radially inside the free liquid surface and downstream the inlet opening has a rear edge portion 31, which during operation is located radially outside the free liquid surface. A line 32 connecting these edge portions 30 and 31 and a tangent to the free  
35 liquid surface at the inlet opening 23 form an angle  $V$ ,

the angle being greater than  $20^\circ$  but smaller than  $50^\circ$  and the vertex of the angle being directed in the rotational direction.

- 5 The tubular elements 27 are arranged movable in the the second outlet device 21 in such a way that the inlet openings 23 of the flow channels 28 can be placed at different radius.
- 10 As indicated in figure 2 this can be accomplished by turning the first discharge device 20 around the rotational axis. The tubular elements 27 are then displaced along their longitudinal axis.
- 15 The centrifugal separator shown in the figures works in the following manner:

In connection with the starting of a centrifugal separator of this kind and bringing the rotor to rotate

20 the separation chamber 5 is closed by supplying a closing liquid to the closing chamber 7 through the inlet 8. As soon as the separation chamber 5 is closed, the liquid mixture, which is to be centrifugally treated, is supplied to the separation chamber 5 through

25 the hollow shaft 14. When the rotor has reached the rotational speed of operation and the separation chamber 5 has been filled up, the components contained in the liquid mixture are separated by the influence of centrifugal forces acting on the same. The separation is

30 then mainly taking place in the intermediate spaces between the conical discs in the disc stack 11. During separation a specific heavier liquid component is thrown radially out towards the periphery of the separation chamber 5 where it is accumulated, while a specific

lighter liquid component flows radially inwards in these intermediate spaces.

If the centrifugally treated liquid mixture also  
5 contains specific heavy particles these are accumulated at the outermost periphery of the separation chamber 5.

The specific lighter liquid component flows over to the first outlet chamber 15 via the overflow outlet 16,  
10 which, thereby, will be determining for the radially level of the free liquid surface in the separation chamber 5. The light liquid component is discharged under pressure out of the centrifugal rotor via the first stationary discharge device 20, which in this case  
15 consists of a conventional paring disc.

The specific heavier liquid component, which has been accumulated at the periphery of the separation chamber, flows radially inward through the passage 8 and further  
20 via the overflow outlet 19 into the outlet chamber 17. Herein it forms a cylindrical liquid body which is kept in rotation. During operation the second discharge device 21 extends radially so far out in the second outlet chamber 17 that such a great part of the tubular  
25 element 27 is immersed in the rotating liquid body that the inlet opening 23 only partly is located in the rotating liquid while the remaining parts of the outlet device 21 is located radially inside the rotating liquid body. Hereby the friction between the outside of the  
30 discharge device 21 and the rotating liquid body will be low.

Specific heavier component flows in through the inlet openings 23 to the flow chamber 26. Therefrom it flows  
35 further out through the central outlet 25.

The through flow area for the specific heavier liquid component, when this has passed through the tubular elements 27, is greater than the total cross sectional area of the flow channels in the tubular elements.

5

In the shown example an interphase in the separation chamber 5 between the specific lighter and the specific heavier liquid component is positioned during operation, the radial position of the interphase being determined inter alia by the position of the two overflow outlets 16 and 19. However, it is quite possible to design a centrifugal separator according to the invention without the second overflow outlet 19 and to let the liquid level in the outlet chamber 17 be determining for the radial position of the interphase.

10

15

Claims

1. Centrifugal separator comprising
  - a rotor, which is rotatable around a rotational axis and forms an inlet for the liquid which is to be centrifugally treated and an outlet chamber (17) for a liquid separated in the rotor, the outlet chamber (17) surrounding the rotational axis and being so designed that liquid present in the outlet chamber during operation forms a rotating liquid body around the rotational axis, which has a radially inward facing circular free liquid surface at a certain radial level in the rotor, and
  - a stationary discharge device (21), which in the outlet chamber extends from the said liquid body radially inward to a central outlet (25) and in the area of the free liquid surface forms an inlet opening (23), which is directed towards the rotational direction of the liquid body and partly is located in the liquid body, the discharge device (21) also forming a flow channel, which connects the inlet opening to the central outlet (25),

25 c h a r a c t e r i z e d i n

that the inlet opening (23) is delimited by an edge, which upstream has a front edge portion (30) radially inside the free liquid surface and downstream has a rear edge portion (31) radially outside the free liquid surface, a straight line through said edge portions (30, 31) forming an angle ( $V$ ) with a tangent to the free liquid surface at the inlet opening (23), the angle being greater than  $20^\circ$  but smaller than  $50^\circ$  and the

vertex of the angle being directed in the rotational direction.

2. Centrifugal separator according to claim 1,  
5 c h a r a c t e r i z e d i n that the discharge device (21) has at least one tubular element (27), which during operation is located in the rotating liquid body with its radially outermost part while remaining parts of the discharge device (21) are located radially inside  
10 the rotating liquid body and in which a part of the flow channel (28) is formed.

3. Centrifugal separator according to claim 2,  
c h a r a c t e r i z e d i n that the tubular element  
15 (27) has a straight longitudinal axis, which is perpendicular to said line (32).

4. Centrifugal separator according to claim 2 or 3,  
c h a r a c t e r i z e d i n that the tubular element  
20 (27) is arranged movable in the discharge device (21) in a way such that the inlet opening (23) of the flow channel is located at variable radius.

5. Centrifugal separator according to claim 4,  
25 c h a r a c t e r i z e d i n that the tubular element (27) is arranged movable along its longitudinal axis.

6. Centrifugal separator according to any of the previous claims, c h a r a c t e r i z e d i n that  
30 the flow channel (28) comprises a central flow chamber (26), which is circular cylindrical and surrounds the rotational axis concentrically.

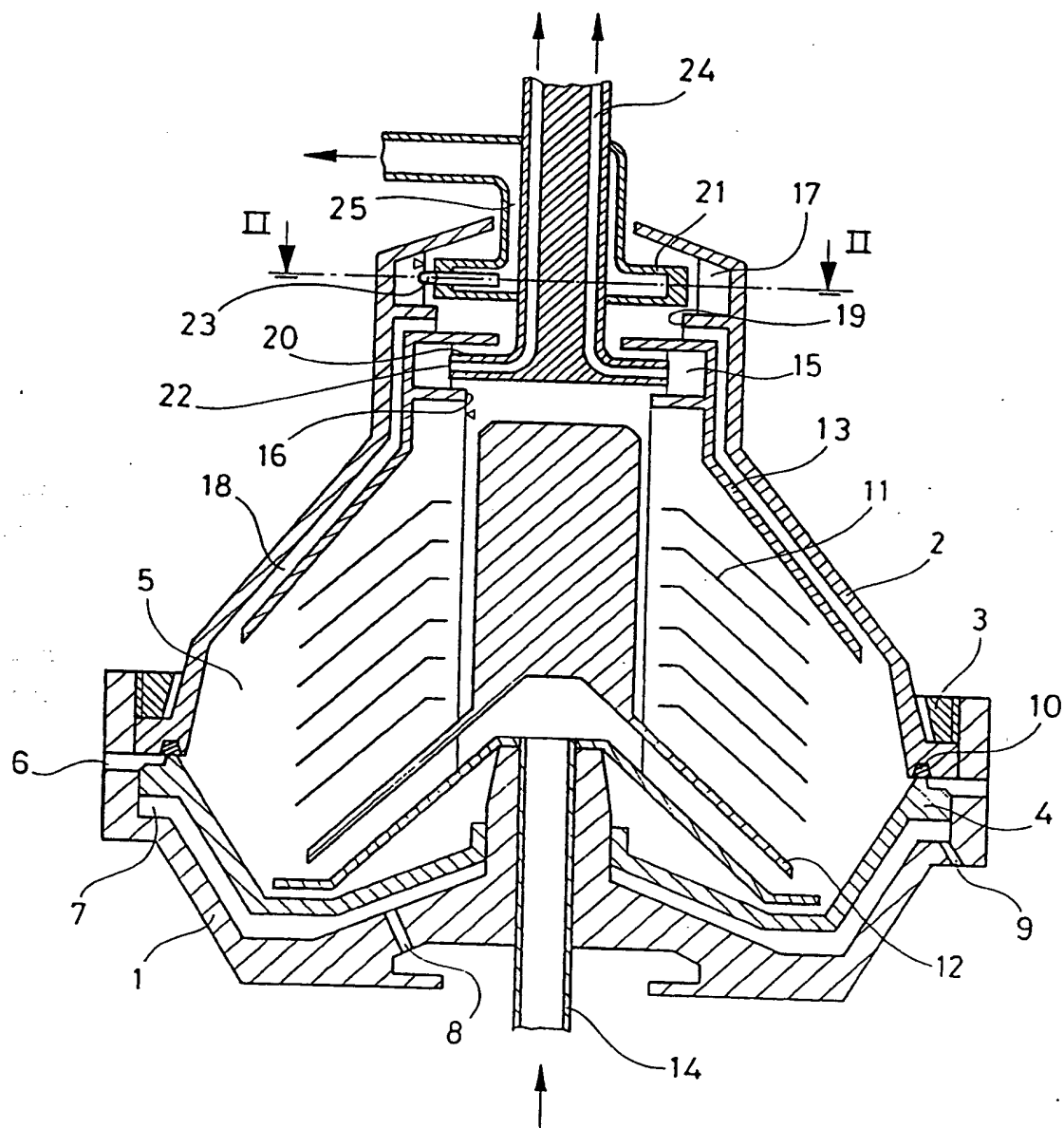


Fig.1

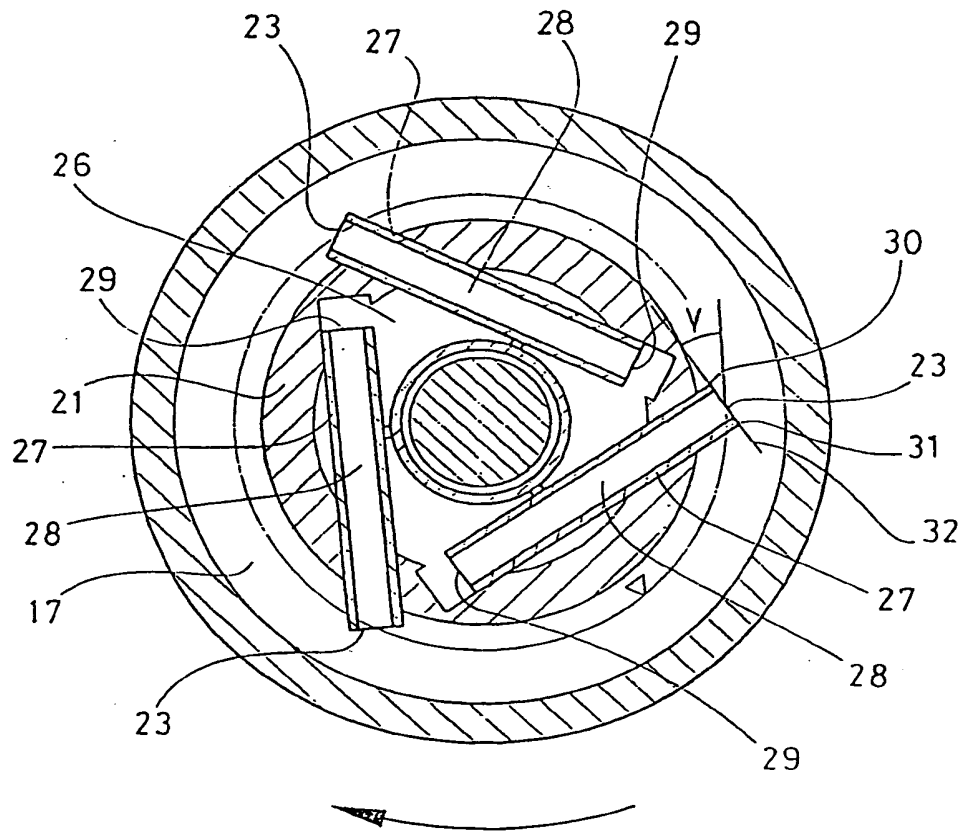


Fig. 2

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00756

## A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B04B 11/08

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## C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A	DE, A1, 3936150 (VEB KOMBINAT NAGEMA), 13 June 1990 (13.06.90), figures 2,3, claim 3 ---	1,6
A	DK, C, 60659 (KOEFOED, HAUBERG, MARSTRAND OG HELWEG, AKTIESELSKABET TITAN), 15 February 1943 (15.02.43), figure 2 --	1,6
A	WO, A1, 8802664 (ALFA-LAVAL SEPARATION AB), 21 April 1988 (21.04.88), figure 3, abstract --	1

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FR, A, 924143 (M. PAUL-JOSEPH THEVARD), 28 July 1947 (28.07.47), figure 2  -----	2-5

**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

27/11/93

International application No.  
**PCT/SE 93/00756**

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
DE-A1-	3936150	13/06/90	SE-A- 8904119	08/06/90
DK-C-	60659	15/02/43	NONE	
WO-A1-	8802664	21/04/88	SE-B, C- 454954	13/06/88
			SE-A- 8604366	16/04/88
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